APPENDIX

Second Air Cleaning Seminar for AEC Personnel

Institute for Atomic Research
Iowa State College
Ames, Iowa

September 15, 16, 17, 1952

GENERAL DISCUSSION OF AIR SAMPLING FILTER MEDIA PROBLEMS

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APPENDIX

GENERAL DISCUSSION OF AIR SAMPLING FILTER MEDIA PROBLEMS

This appendix is based on a general discussion of air sampling filter media requirements which took place on Wednesday, September 17th in this Seminar and were wire recorded. The resulting transcription has been edited by Dr. Leslie Silverman who acted as panel chairman and have not been reviewed by the respective discussors in order to expedite publication. Any comments are the personal opinions of the discussors and do not reflect the views of the U. S. Atomic Energy Commission or its contractors.

The discussion is divided into two parts. The first, a general discussion of the problem and the second, a panel discussion by representatives of several major AEC activities on the problem of filter media and a consideration of specifications for types of media to be used.

Requirements for Sampling Filters

Leslie Silverman

What are the requirements of a sampling or filter media? (See Table 1) We have something which might look like Professor Lapple's discussion yesterday in regard to sand and Fiberglas, but we are not dealing with a size of 85' x 85' but a maximum of 85 square inches. In cost we are not dealing with thousands of dollars but with only a few cents. Nevertheless, we do agree that there is a common efficiency basis. Here, however, we are not as vigorously bound by efficiency demands because no hazard to man is involved as at the discharge of a space filter. In other words, the efficiency that we desire is one of convenience and accuracy. When I say convenience, I mean that we should have a paper or medium that will give reproducible efficiencies rather than worrying about absolute values or approaching 100 percent. It is very nice to have a 100 percent value to avoid correction of values for concentration, but we will settle for 99 or even 95 percent because from a health consideration or atmospheric concentration values plus or minus 5 percent in the final results

is not critical.

I do not know, after listening to Mr. Rodgers last night, whether the purists at Argonne are going to stand for plus or minus 5 percent in sampling work but I hope they will. The problem of efficiency then, is more of constancy rather than of extremely high value. In practice, I think anything above 0.9 or 90 percent would be considered satisfactory as long as it remains 0.9 with a known standard deviation.

The problem of resistance to air flow is also not any real handicap. We are not hide-bound to keep our power requirements or consumption at low levels as in air cleaners. We like to have them low simply because the types of pumps or air movers that we can use in the field are limited and we do not want to carry heavy equipment such as high pressure blowers or vacuum pumps. It is desirable to have resistances which are convenient for ordinary types of sampling equipment. We can operate with resistances as high as one-half an atmosphere, but under ordinary circumstances we prefer to keep below 2 inches of mercury even for high volume units (1 to 2 cubic meters per minute). Millipore media, (if you use the HA type in 50 mm circles) may run as high as one-half atmosphere at the cubic foot per minute rate.

The next problem is that of uniformity, this is one of the most important items from the standpoint of both efficiency and resistance. We have found, in the past, that it is easier to get uniformity with regard to efficiency than it is to resistance. If one takes a box of analytical papers, for example, say Whatman No. 42 and tests that box by taking papers at random and checking their air flow resistance, it will be approximately 1 inch of mercury $\pm 10\%$ at a cubic foot of air per minute for a 3 inch diameter disc. You might take another box from another mill run and find that it will be 2 inches. In other words, it depends on the manufacturing, the lot,

and the conditions of manufacture which were followed. Yet, the filter efficiency for this variation may be reasonably reproducible. If we were able to exert control on the production of these papers and do testing such as is done in the case of paper mills that are now making AEC or CC-6 paper, we could perhaps get uniformity in our sampling media. We haven't uniformity in use yet so we cannot hope to get uniformity in production until we have some limitation on the variety of papers in use.

The next problem is that of penetration. Now, by penetration, I don't mean the penetration we usually talk about or the value of 100- efficiency. What I mean is how far do the particulates penetrate below the paper surface. From the standpoint of chemical analysis where one may do a complete destruction of the media; this is not too important but when counting radioactive materials it is important. The so-called absorption factor is involved and if we were able to keep all the particles on the paper surface we would be in a better position. At least, from the standpoint of those people who are concerned with alpha counting.

Now as to discussing filter life. Life and penetration are really tied together. That is, a filter cannot have minimal penetration and still have long life. We would like to keep everything on the surface and yet not provide a barrier at the surface which will have high resistance and not only produces absorption from the media itself but mutual absorption between particles. In order to obtain long life in air sampling filters a deep bed with high void volume is necessary. As a compromise a napped surface is usually possible on a flat media which improves life without seriously affecting efficiency.

For ease in analyses, chemists prefer to have the two requirements I have given in Table 1. Low-ash, because they want minimal entrainment of their dissolved materials and to speed extractions they like to have a media

TABLE 1

Requirements for Air and Gas Sampling Filter Media

A. Desirable Characteristics

1. Efficiency (High and reproducible)
2. Resistance (Low and compatible with ordinary sampling pumps)
3. Uniformity (Reproducibility in manufactured lots)
4. Penetration (absorption) (Minimal surface penetration, compatible with low resistance and high efficiency.
5. Life (Long and compatible with items 1 and 2)
6. Ease in chemical handling
   a. Low ash
   b. High solubility
7. Thermal Resistance
8. Moisture Resistance
9. Low cost (Depending upon particular application and type of sampling)

B. Types of Operations for Which Filter Sampling Media are Used

1. Routine environmental monitoring
   a. In plant or near processes
      (1) Static or single fixed media - High volume rate
                                        Low volume rate
      (2) Continuous or moving strip media - High volume rate
                                             Low volume rate
   b. Outside plant or operations
2. Stack sampling
3. Particle sizing
4. Background monitoring
   a. Static or single fixed media
   b. Continuous or moving strip media
5. Air and Gas Cleaner Rating

c. Types of Air Sampling Media Used at AEC and Contractor Sites

1. Cellulose media
   a. Analytical Filter Papers
      (1) Whatman No. 1, 41, 42, 44, 50
      (2) S & S 589 and others
      (3) Munktells 00 and others
      (4) Eaton and Dikeman 613 and 623
   b. Molded forms
      (1) Paper thimbles
      (2) Type S pleated filter (MSA)
2. Cellulose - Asbestos
   a. Hollingsworth & Vose HV-70 9 and 18 mil
   b. CC-6 or AEC No. 1
3. Glass Fibers
   (a) Hurlburt glass media
   (b) Catalog 800 Fiberglas - Corning Glass Company
4. Millipore Filters HA and AA (Lovell Chemical Company)
5. Miscellaneous
   (a) Cotton plugs
   (b) Asbestos paper
   (c) Asbestos fiber pads
   (d) Synthetic fiber papers and plugs.

readily soluble in convenient reagents. That is, using wet digestion with ordinary acids or solvents rather than having to use fluxing and other elaborate procedures.

Items 7 and 8 in Table 1 are thermal and moisture resistance. These factors are important when sampling stacks where we have high temperature effluents or sampling from such devices as incinerators, especially before the cooling processes. In other words, a sample taken above the incinerator involves gases in the range of 1000°F and higher and without cooling before sampling requires temperature resistant media selection.

Moisture is a factor because media used in saturated streams causes paper to swell or saturate. In conditions encountered in some collector effluents will cause the media to absorb moisture and change its flow characteristics or actually plug.

The last item is the economic factor and is dependent on the amount of sampling to be done. The amount of paper that goes into one large CC-6 space filter (200 square feet) would probably last the ordinary laboratory site a month. Cost is therefore not a critical factor with efficient media but if requirements are high, the cost factor may become important. At the present time millipore media is the most expensive. We have this filter media at the upper end of the bracket which costs dollars per square foot and have other satisfactory media which is on the order of cents per square foot or less. I think these represent the extremes in cost of sampling media. As far as I know, the most widely used media in sampling work has been the HV-70 paper and that is relatively low in cost. I think Mr. Stafford can say more about the cost aspect of this when we have our discussion later.

There are certain factors about the aerosol that are certainly going to effect items 1 through 8. We know that the so-called 5 S's of the

aerosol namely; size, size distribution, shape, specific gravity, and the surface characteristics will have some effect on resistance and efficiency. The concentration of the aerosol is also a critical factor in sampling because it will determine whether or not a surface of aerosol is formed which will then be doing the filtering. Obviously, the life factor and the loading are also dependent on the volume passed through the media. In other words, we are actually talking about whether high or low volume sampling is the major factor in determining the life rather than any other factor. The amount of a given media which can be presented to the sample air stream is a function of the size of the media holder, its shape and other dimensional factors.

Media in use at the sites and contractors.

I have summarized these in Table 1 although those present may have some additions to this list. Whatman papers number 1, 41, 42, 44 and 50 have all been used for air sampling purposes. We know that other analytical media such as the S & S (Schliecher & Schull), Munktell, Eaton and Dikeman and other papers have been utilized. These have been used as flat sheets or they have been used in the form of thimbles made from pulp. From the standpoint of special papers, we have the Hollingsworth and Vose HV70, used in 9 mil and 18 mil thicknesses. I hope that we can find out why one site (Argonne) is using 9 mil and the other site (Los Alamos) is using 18 mil. We have the so-called millipore media (MF) which has come into use quite recently. The millipore media is available in the so-called hydrosol-assay (HA) type and in the aerosol-assay (AA) type.

I think we all owe a vote of thanks to the Chemical Corp Biological Laboratories at Camp Detrick for getting this media developed and produced through their contracts with California Institute of Technology and the Lovell Chemical Company that investigations were initiated and carried out.

We have some all-glass paper media which is now available. Mr. Decker of Camp Detrick was kind enough to give me some information on a commercial source. I will abstract it for the group so that they will have some idea of its composition and performance. The last materials used for sampling have been miscellaneous types such as cotton synthetic and glass wool fibers in the form of pads or plugs.

You recall we talked yesterday about using 3 stages of glass wool plugs. This idea goes back to the early 1900's and in addition to glass, cotton, steel wool, and various other fibrous media have been used. Another type of sampling that has been done in industrial hygiene work has been the use of gooch crucibles with asbestos fibers in the form of a pad. This is considered as a very efficient filter. I think, from Mr. Smith's discussion, that you can see why. Then we have an all-asbestos media, which the A.D. Little people and others have made which has certain advantages and certain serious structural limitations.

I have probably covered most of the media but the selection and reasoning behind the use of these media are the principal items intended for discussion this morning.

What information is available on the efficiency or performance for the various uses of these media? We have efficiency information from various sources. I hope I do not slight anyone in trying to enumerate these results.

At Harvard for several years we have studies filter media for air sampling of industrial environments. Ten years ago we investigated filter papers for lead fume and dust sampling and there were limited investigations in Europe before that time. We measured the performance of the Whatman series and some other manufacturers' products for lead, iron, fluorides, zinc and cadmium fumes. The principal papers we investigated then were Whatman's 42, 44, and 50.

After that time, apparently during the war, the Rochester group, in doing certain Manhattan District investigations, selected Whatman No. 41. I was quite interested to find out why Whatman 41 was used so when I visited Rochester a few years ago I inquired, and as far as I could determine there was an analytical chemist at work there that decided that they were going to use filter paper for sampling. He hunted through the drawers and found some Whatman 41. This has been the choice of Rochester ever since. Years later, about 1949, they decided to determine the efficiency of the paper for various aerosols. Sid Laskin did that with uranium aerosols and sodium chloride. The New York Operations Office, Bill Harris' group, have also completed a number of investigations using Whatman 41 on uranium aerosols and have also used it extensively in the field. There are some objections apparent from the critical examination standpoint with regard to Whatman 41 paper in that the papers show obvious pinholes and are low in surface uniformity. I think Mr. Harris can probably tell you the extent of the variation.

The Camp Detrick group have investigated various media. I do not know all their answers because I do not think they have been presented. They were largely responsible for the millipore or molecular media, which we have found has several desirable characteristics. Efficiency with that medium is no problem and neither is penetration since it is really a true sieve. Hence, the paper yields high efficiency but rapid surface buildup of the aerosol. Obviously, this characteristic is going to be detrimental from the resistance and the light absorption or reflection measuring standpoint.

We have seen results of work done at Knolls with regard to Whatman 41 millipore media and HV70. Work was done at Argonne during the days of the Metallurgical Laboratory on HV70, primarily with regard to its use in

radiological physics monitoring work to determine the absorption of the paper for alpha counting. As far as I know, there have been a few investigations at other places for which we do not have much efficiency information. Brookhaven is using a continuous HV-70 strip but I do not believe I know of any performance data that they obtained on efficiency of media, particularly HV-70. Some work is being done at Oak Ridge with regard to efficiency of various media. In the Handbook on Air Cleaning you will note that there are some data on radioactive aerosols removal which were taken from work done at Oak Ridge by John Goss and others. I believe it is really Ed Struxness' group. If I am correct on that I think Ed or Bill Baumann can verify it.

As far as I know, most of the work at the other sites has been of a field or empirical nature and I think they will report on them during the panel discussion.

I do not have much more to say about media so I hope when we have our panel group here each man in the group will discuss his own requirements and the reasons for selection of media.

I have this letter from Hurlbut to Mr. Decker which I would like to abstract because it gives up-to-date information on all-glass media. We have not been primarily concerned with all-glass medium sampling except we know that it will satisfy requirements seven and eight (Table 1) very well. This is a description of one type of paper made solely with ultra-fine glass fibers. The company which makes this paper happens to be the Hurlbut Paper Company located at South Lee, Massachusetts. I understand there are three other paper companies making this type of paper primarily for electrical insulation, not filtration. As Mr. Smith pointed out yesterday, glass media may be high in cost but I think that this is a situation which will depend upon demand. The source of these

filter fibers that Hurlbut used is Glass Fibers, Incorporated of Toledo. The paper is described as X935B. The paper is manufactured of glass fibers with a diameter ranging between 0.2 and 1.5 microns. The fibers are made of E glass, which has a melting point somewhere around 450°F. The X935B paper contains a binder of rubber-like nature. This gives good physical properties and high chemical resistance and strength. These are all factors which might also affect its use as a space filter as well as in air sampling. The internal bond strength, the tensile strength, the impact and shock resistance of this paper formulation is better in comparison with 50 other binders tested at Hurlbut's laboratory. The chemical resistance of the paper is excellent and the paper can be immersed in water or 10% solutions of hydrochloric acid for a long time without appreciable loss in strength. The same result was found for sulfuric, acetic and nitric acids.

It was determined by two independent laboratories that crushing, rolling, bending and quite rough handling of the paper does not impair the air filtering properties. It was rolled, for instance, between the palms of the hands for one minute and the efficiency of the paper checked afterwards. The DOP efficiency was the same. For the X935B paper, tests show that DOP penetration was less than 0.005 percent. Exposure of the paper to 400°F does not impair the air filter properties at all. It was found that the pressure drop was approximately 1 inch of water at 5 feet per minute. The pressure drop improves slightly (drops 5 percent) after exposure to heat. Exposure of the filter at about 1500°F would melt the fibers and destroy the filter. Other fibers, in experimental production, may in the future allow the manufacture of filter paper which would be able to stand temperatures up to 3000°F. The results obtained so far at Hurlbut and checked by other laboratories, indicate clearly that the manufactured glass fiber paper has a bacteria arresting efficiency of 99.999 percent.

This development makes glass fiber paper usable therefore, for several sampling applications. We now have available a wide variety of papers and several are used at the different sites. We would like to get some approach to limiting the number of papers used and try to standardize and get consistency among the AEC organizations doing air sampling. If this is done, the results can be readily interpreted in the same light. We are not trying to close the door to new media. I would feel that today we have the answers to almost all of the air sampling filter media problems.

A year ago, when we had our first Seminar, the same problem came up and it was proposed that we would have some kind of a meeting to decide what should be requirements for the papers needed. Mr. Stafford told us then, and I am sure he was correct, that he can produce any kind of paper in terms of cellulose or cellulose-asbestos combinations to meet the requirements we have stated here (Table 1) at least through item 6. The question of temperature and moisture problems arise in certain special instances. The problem of using paper for particle sizing and background counting of low orders brings up questions of selecting millipore or speical high surface efficiency papers. That, in general, is all I intended to say about sampling media.

General Discussion on Sampling Media

The best way, I believe, to have our discussion is to call those on our panel and have each member discuss types of paper they use in their operations and reasons for their choice. I will be glad to answer any questions now pertaining to what I have said this morning.

Question: (Anonymous) Does glass paper have any advantage over cellulose containing paper in measuring changes in weight in gravimetric sampling:

Leslie Silverman: (Harvard) Glass papers show little or no absorption but I think there is always some adsorption. I might point out that this glass paper

was largely done at the initiation of the Naval Research Laboratory and through their efforts the fiber manufacturer has been able to produce these superfine fibers. My opinion is that absorption is practically nil on the glass but adsorption still remains as with other sampling media. If you can get equilibrium before weighing, then it will be a big advantage to use all-glass paper.

I have neglected here, one paper which I should have mentioned, that is the so-called type S paper which is used in high volume sampling which is a cellulose-bagasse mixture. It contains no asbestos and uses the bagasse for high wet strength in formulation. We have some efficiency data on these and I believe NYOO may have some to report.

Question: (Anonymous) Who makes that medium?

Leslie Silverman: (Harvard) It is made by Mine Safety Appliances Company. It is actually an application of the Hawley process for making paper maché forms but the cellulose fibers are mixed with the bagasse fibers and sucked onto a screen making the pleated filter as shown in the Handbook on Air Cleaning, passed out to you this morning.

One thing I would like an answer to is "Why Los Alamos uses 18 mil HV-70 and why Argonne uses 9 mil HV-70?" I understand from the manufacturer that both are made to the same resistance and penetration specifications. In other words, some changes may be made primarily in what I think would be the penetration characterisitcs. Both media have the same so-called Navy or Army Chemical Corps efficiency-pressure drop ratio.

In addition to those data I mentioned earlier we have some data which was obtained on chromic acid mists and lead fume with layers of different papers. We also have a project on lead fume removal for various papers which is sponsored by a smelting company in our laboratory. That investigation is going on at the present time because some of the papers on which we now

have adequate efficiency data are too high in resistance for field use and more air flow for the given size filter and holder is necessary.

Panel Discussion

Panel: Leslie Silverman, Harvard - W. B. Harris, New York Operations Office - Frank Adley, Hanford - Edwin P. Hyatt, Los Alamos - Walter J. Smith, A. D. Little, Co. - G. O. Payne, Argonne - Willard Baumann, Oak Ridge.

Leslie Silverman: I think perhaps the group that have used Whatman 41 the most has been NYOO. I would like William Harris to discuss what and why they have selected for sampling filter media.

Mr. W. B. Harris: (NYOO) In the first place, I believe that the matter of efficiency is primarily one of selected rather than overall efficiency. I do not think it makes a great difference whether our filter papers are 90 percent or 80 percent or 50 percent efficient, as long as they are reproducible for all types of material. We are willing to accept, for example, radiometric counting where we know that we do not get more than 70 percent of the actual material counted so that at best we are looking for 70 percent efficiency. Now the variability in that is great. I believe that the studies we have done indicate that 70 percent efficiency is ±10 percent on individual samples. It also depends on the type of material, its air concentration and particle size and several other factors. I would limit our efficiency requirement to a requirement of consistent efficiency for all types of material. One of the items which I feel is very important, which Les did not mention here is the mechanical strength and the ease of handling the paper. Our people on a survey of installations take several dozen samples and unless the sampler holder and the operation of putting the sample in and out of the holder is simple and the medium is strong you ruin the sample. I believe, therefore that strength is a very important consideration in development of paper media.

Another thing is the simplicity of the paper holder that we use for the

paper. Where we know samples have to be taken and paper has to be placed in and out of the holder rapidly it is important that this be a relatively simple matter. New York has been using the Whatman 41 paper for what I believe is a very good reason. About 5 years ago we were under the influence of Rochester (University of Rochester) because this institution, at that time, was the only real high-class industrial hygiene laboratory made available to the Commission. When we set up our health unit there were three people in it, an M.D., an instrument man and an industrial hygienist. The instrument man right away decided that he would make sure that we have enough equipment to do our sampling so he asked Rochester what to use for sampling. They said they used Whatman 41 filter paper so we contracted for this Whatman grade and got what I believe, I have never obtained the exact number, but it must have been about 50 million pieces of 1 1/8 diameter of Whatman filter paper. I say it must have been 50 million because it is now 5 years later, our program has increased and the little boxes of 100 papers each are still there. You can imagine why we have a vested interest in Whatman 41 filter paper. I suspect that by now we must be getting somewhere near the end of this but I am not sure. Now as for the measuring of efficiency, we have been very anxious to get a good measure. However, I must admit that despite Les' recitation, that all of the places that have done efficiency measurement, I do not believe there has ever been an effective measurement of the efficiency of any of these media, and by effective, I mean one which in a concrete manner takes everyone of the variables and eliminates them. I do not believe we have any good idea of the efficiency of any of the papers by particle size. What is the difference in efficiency between a particle size of 0.05, 0.1, 0.5, 1 micron and 5 microns. We should have a performance curve of that. We should know the variability of size so that when we are in an atmosphere which is primarily particles less than 1 micron, we can interpret the sample

in definite distinction to a sample which is taken in an atmosphere where particles are primarily over 5 microns. We do not know accurately what is the efficiency of the paper with changes in velocity through the paper. That has never been accurately defined. There have been a number of various types of a given media and they vary. They are not the same. Some work which LaMer did, indicates that the curves go up and some work which Tracerlab did indicates that the curves go down with increased velocity. I believe that work which was done at Rochester indicated a peak in the curve. There is certainly some variation in velocity, superficial velocity through the paper with which I am not satisfied at all.

There is the matter of measurement of counting efficiency of the paper, in other words absorption, either self-absorption or internal absorption. We have done tests and have some results. Just as we have performed efficiency studies and have other results. We have done them with a practical approach in mind. We know that it is not a scientific approach. We hope to be able to do it in a manner which is scientific but we have not had the time.

For example, we did a pretty good study on the efficiency of Whatman 41 against the materials that we normally run into in our plants such as the uranium salts and oxides. We set up atmospheres that had substantially the same particle distribution that we find in the plants, according to the Cascade Impactor, something like 2 or 3 microns mass median. We measured high efficiencies and they were consistent with all our runs. The efficiencies were better than 98 or 99 percent. We felt the samples taken must be reliable. I am sure that there are many types of materials that we find in the plant for which this paper (41) is not good). Also, we did the same kind of thing for the degree of absorption in the paper. We went through our files and picked out about 500 samples and we picked them deliberately in low, medium and high range of activity on samples with I believe 0 - 10 micrograms, 10 - 100

micrograms and 100 - 1000 micrograms on a sample. We picked them from areas that had primarily a hydrolized fume, UO_2F, which is supposed to be of very small diameter; with a uranium oxide fume which is on the order of 0.01 micron and with uranium dioxide and uranium tetrafluoride. Those samples were all counted again, the original counts were checked and they were then analyzed chemically. From this we got an analysis of the amount of penetration into the paper. We used a 70 percent figure because it looks like the best fit. We are reasonably confident that most of our samples would fall in that area. On a basis of that, we have put some confidence in our results. However, we have tried to evaluate by the elimination of variables that absolute efficiency of Whatman 41 and of other papers. We have found that against the molecular filter, the Whatman 41 does not do very well where the material that we are collecting is extremely fine. One of the pieces of work that we did was in conjunction with another study on the sampling of daughter products of radon and thoron. We set up atmospheres of radon and thoron and have attempted to measure their concentration by means of the collection of their daughters and measurements. We at first cleaned the area of dust and took samples and it took us a long time to find that we had not quite cleaned it out because when we finally got the area clean of other dust it was very difficult to find the radon and thoron. I think we have pretty well established that radon and thoron are picked up on other dust particles, so that the results that we got in that study are not of much value inasmuch as we cannot define our starting material. We did use the millipore filter, and the all-glass filter, both the extra fine glass about 0.7 micron a more rigid paper (averaged about 1 1/2 microns) I believe. We used some paper which was made up by A. D. Little, which contained all asbestos. It was a very thin membrane of asbestos on a grid support. We found that all of these media gave us a considerably better retention. We measured alot more

on these samples than we would with Whatman 41. I am convinced from these studies that although Whatman 41 is a less efficient filter (by the way, that also holds true of HV-70) we got much poorer results with HV-70 than we did with these other presumably finer filters. The HV-70 was somewhat better than Whatman 41 but not a great deal. I am sorry I cannot give you any numbers on these. It was just work that was never really very extensive.

Leslie Silverman: (Harvard) We are glad to know the Whatman 41 story. I hope it might be convenient to utilize surplus to eliminate the poor efficiency paper.

William Harris: (NYOO) I would like to say it is not a poor efficiency paper. On industrial dust it was a good efficiency paper it showed better than 98 percent and consistently so and the material is extremely economical. I am sure, however, that there is a big variation in particle size efficiency.

Leslie Silverman: (Harvard) I would like to make one comment on what you said. It would be very nice to have all this particle size versus efficiency studies but we do know that most of these media are going to give high efficiency down to 0.3 micron when using the present DOP test. Now, I for one, am not convinced that the DOP test is the answer to this problem because it is a liquid aerosol and I think you get a completely erroneous impression of the performance of a media if you depend on a liquid aerosol alone. I think the answer, which might be an adjunct to what Bill Harris said is that we should have these efficiencies over a range. The solid aerosols of the type encountered in practice are the ones that he has gone a long way towards getting answers for their particular problem are the ones to use for tests. Many similar type dusts are encountered in other AEC sites and therefore, the information that they have will be very useful.

Considerable amount of work on high efficiency sampling filter media has been done at Oak Ridge.

William Harris: (NYOO) I would like to say something in addition to what you said, if I may.

Leslie Silverman: (Harvard) Surely.

William Harris: (NYO) I agree with Les 100% in that any stock that we place in DOP testing of these papers is not well advised. Testing with the liquid aerosol is not the answer to our problems. On the basis of this, the NYO has just concluded a contract with Victor LaMer at Columbia to produce a piece of test equipment which will do exactly what the DOP tester will do except with a solid aerosol. In other words, an aerosol which can be measured with the optical analyzer and is easily generated in a generator and sized optically the same way the DOP is handled. I believe that he can do it as he has indicated and when it is finished it will be a very useful tool for everyone.

Leslie Silverman: (Harvard) I think there is one thing that Mr. Stafford and Mr. Smith are going to point out that I think they will go along with some of our needs here but will also point out that the DOP test is a very useful aid in manufacture to control uniformity and from that standpoint it has a considerable merit. What I was going to say before was that Oak Ridge has done a fair amount of work in this field and they are continuing the work and Willard Baumann has agreed to say a little bit about the work that they are doing.

Willard Baumann: (Oak Ridge) Well, the history of filter papers at Oak Ridge is based upon the DOP test and was started off using Whatman 42 and 44 because they showed low penetration with DOP. The reason they used the DOP was because there was another program going on down there, "the protective equipment evaluation program" and anyone that has used the DOP knows that it is pretty easy to use and you get rapid results. How good the results are, what they mean, may create some objection. We started to use the 42 and 44 papers and the reasons we did not like them was because after we had used them for some time they gave high resistence. We were limited because we were using 1 inch discs of paper and we wanted to get more airflow through the paper so we decided to investigate other types of paper. Using the DOP rig, we

investigated Whatman 41, 42, 44, 50 and HV-70. We also investigated, I think, a polyethylene filter that the Chemical Corps. loaned us. All these results were written and summarized in one of our progress reports. Based upon the work that we did, we decided for Alpha uranium materials, to go over to HV-70 paper using a single thickness and a 9 mil paper. This was based mostly on our DOP work. We found that with DOP we got high efficiency and good air flow characteristics through HV-70 paper. We also confirmed the work that Laskin has done, namely when we increased our velocity through 41 paper we found that our penetration decreased. At the present time we are using HV-70 paper for all our Alpha emitting contaminants and we are using Whatman 44 for beryllium, (Beryllium is really our only non-radioactive material with which we have to contend). One of the reasons we decided to do this testing was because we could not find anything available in the literature. We were like Bill and the others, when we tried to find anything in the literature it just was not there. Whatman 41 was being used but we did not like it because it gave high penetration. We decided to build a dust box and we hope to evaluate our filter papers again. What we are using in the dust box is a heterogeneous uranium. I think it is U_3O_8 and at the present time some of the early cascade impactor samples indicate that it has a mass median diameter about 7/10 micron.

John Gallimore has done some of this work and we have not done enough to report on. What he did find out was pretty interesting and he has some counter efficiency data. We have been using for HV-70 based on field experience, a count efficiency of about 70 percent. We found similar results for his test work using HV-70; using Whatman 41 paper he got about 50 percent. (As I understand, Bill Harris gets about 70 percent). With the millipore filter we got 88 percent and with No. 44 64 percent and with CC-6 paper we found 82.5 percent.

Our program will consist of checking all these papers for efficiency.

We are going to use an aerosol that we encounter in our particular installation namely uranium salt and see how well we can control concentration and particle size in this dust box. I guess we will find that out in time. Probably, after we get some figures we will continue to use the HV-70. I might say that we are using every type of paper in our work. We are using high volume samples with 41 and pleated paper. The only thing that runs consistent is for beryllium and there we continue to use No. 44.

Leslie Silverman: (Harvard) Do you feel there is enough advantage in the millipore paper for counting to stick to that for Alpha?

Willard Baumann: (Oak Ridge) The only trouble with millipore media is cost. It is very expensive since we are processing roughly between 100 to 200 samples per day. If we restrict it for beryllium we might be able to use it but there would be no advantage because we use a spectrographic method and Whatmann 44 has fairly low ash which fits our requirements for beryllium.

Leslie Silverman: (Harvard) Was the millipore used AA or the HA?

Willard Baumann: (Oak Ridge) This was HA. We have AA now and we will probably check it soon. I do not know whether there will be any difference.

Leslie Silverman: (Harvard) Bill, do you know which one you had?

William Harris: (NYOO) We have had both. We only used a few papers. I have two objections to their use, one of them is that in using a couple hundred per day the cost is tremendous and the other is the mechanical handling. It is brittle and hard to get in and out of the holder. It is just a difficult thing to handle. On a productive basis, where you are turning out hundreds of samples a day, it does not work well.

Leslie Silverman: (Harvard) Our primary application of it in our work is for particle sizing and direct microscopic examination. Its unique value is that you can flood it with immersion oil and get transparency and thus see agglomerates as they were collected. No other technique has enabled us to detect

agglomerates in aerosols after collection. This, as far as we are concerned, is one of its outstanding advantages because we feel that we can get high efficiency at far less cost. For particle sizing work I think it is unique. It also is soluble in acetone which is an advantage in chemical work.

Walter J. Smith: (A. D. Little) I would like to talk a little first about the DOP tester. I agree it has certain drawbacks but if it was not for the DOP tests we probably would never have gotten anywhere. An extremely rapid way of testing samples from the time we start to prepare a paper formulation in the laboratory until we have an answer to its penetration can be as little as 10 minutes. In that way, you can go through experiments pretty rapidly. I do not think it is any exaggeration that in the course of our paper work we have made many thousands of hand sheets. At one time we feared also that the DOP tester was probably giving us something that would not be comparable with the results you might get in practice so we worked with cascade impactors and finally got a model to our satisfaction and compared it with the DOP results. In general, for submicron sized particles of atmospheric dust, there was always a different correlation. If DOP penetration was in the order of a few hundredths of a percent so was the atmospheric dust penetration of submicron size as determined by particle counts on an impactor slide. By comparison for a result of that kind we might have to run our pack on such clean air for many hours. The counting is tedious. You can never depend on one count and without exaggerating the situation one bit I would say that there have been times when we have spent two days getting a single answer of efficiency per paper compared with the matter of just minutes on the DOP. For that reason, for routine work, the impactor did not fill a very big place. On the other hand, we all know that there are particular media which show after the DOP tests had been operating a while, that penetration increases. In the case of the millipore filter the surface appears to fill so rapidly that you do well to get a reading at all. The effectiveness of the DOP tester, I think, is brought out

by the fact that the manufacturers of the space filters all have a DOP tester, a large one. They have a huge smoke generator and pass DOP through the complete unit, 1000 cfm and take a sample before and after. It is a rapid way of telling whether a particular filter is acceptable. I have watched them with an inspector from one of the areas testing filters for acceptance and almost as fast as they can handle them they can tell whether they are over or under the specification.

Two years ago, Mr. Stafford and I made a tour of the areas and among other things we asked about the test and monitoring filter practices. We came away with a distinct feeling that there is plenty of room for improvement, especially on simplification. It seemed that everybody had his own ideas of what should be used and in some cases we felt that they were not using the best thing. A choice in some cases was dictated by the matter of availability, if a man could open a drawer and take out a piece of filter paper, well, that is what he used. In other cases, there was a reason for particular choice and we found one case, as Les did, where some authority in the forgotten past had decided on what should be used for a paper and it was carried on. In a few cases, we had the suspicion that the person felt his work was so important he just needed something different. There is opportunity for simplifying and giving everybody what he wants. For the past few years there have been so many new developments in fibers I think you can probably give every person with a separate project a different filter.

Sometimes I think there is probably a real need for a special paper and just the past 6 months I have been impressed with the determination of one laboratory to get a certain filter. I think it would be well to take the time to tell you about it. About 6 months ago I think the first request was for a set of characteristics of some samples. Mr. Stafford made out a few sample sheets and sent them out. This was to Los Alamos. About 3 months later we got a request for a quotation on 100 sheets each of those from the Purchasing

Office of the University of California and we wrote back that we were not in the business of making the paper and we did not have them in stock. They insisted, however, that we provide a quotation. Well, we could not do that working under AEC Contract so we said perhaps we could make them up on our contract. I tried to find out who the man was that wanted them. I thought I knew him from the previous correspondence but I could not locate it so I took a chance and we made up 50 sheets. I thought that would take care of it but very recently we received a request to please complete the order.

On the matter of fine filters, I think we all know what the absolute type filters can do and the only thing that I would like to add to that is this - that we get the impression from all this that we are working with nothing but mineral fibers. That is not necessarily so. There are some cases where it is necessary to digest or incinerate a filter in order to get a gravimetric result or to recover something that is caught. It is true that most of the present work has been directed toward fine glass fiber or asbestos fibers because they are cheap and easily available. There is a distinct possibility that the organic fibers, which are also being made in finer and finer dimensions, could be used for this purpose and we have done enough to convince ourselves that you can make an all-organic medium consisting of coarse fibers supporting finer fibers or also organic fibers and get efficiency similar to the absolute papers. I just point that out because some of these fibers have to be disposable after they are used.

Leslie Silverman: (Harvard) We have had sent to us, not too long ago, some papers made out of Dynel fibers, which apparently will pass the DOP test with high results. We also have Polystyrene, Polyamide, and Nylon fibers all in the range of a hundredth of a micron to half a micron and it is quite possible now to made chemically soluble filters from these micro-fibers. These will dissolve in acetone, carbon tetrachloride or a suitable solvent. Again now it is a

matter of these fibers being only an experimental production item and our demand for air sampling uses would never satisfy the requirements manufacturers would like to have. It is possible to get papers made on a hand sheet basis of any of these superfine synthetic fibers. I do not know what particular advantage one plastic has over another but they have thermal and other physical differences. Most of them are not too high in air flow resistance, but the ones that are completely chemically soluble provide a means of getting your sample in solution and elutriating your sample from the solution or the solvent if you want to make a particle size separation. They do have some other attractive features. We still do not have a good sampling media as a filter which can be placed into the electron microscope for micrography work. We hope that in the near future we can get millipore media in a thickness that will permit it to be put right into the electron microscope and not offer any background shadow. It looks as though it might have some promise. One field where these organic fibers will appeal to the chemist is in ashing where there is no significant ash to bother their analyses.

Los Alamos has been doing a large amount of air sampling both on the site and off the site and Mr. Edwin Hyatt of their industrial hygiene group is here in place of Mr. Harry Schulte, who unfortunately is ill. He will make a few comments on their problems at Los Alamos.

Mr. E. C. Hyatt: (Los Alamos) The most pressing question that you had Les, was why does Los Alamos use 18 mil HV-70 and Argonne 9 mil. You asked this some time ago and I have been asking around Los Alamos. The industrial hygiene group has only been there about 4 1/2 years but it goes back before them and we are trying to lay it in the lap of the army. The routine sampling has been used since the day of the Manhattan Project at Los Alamos. There are pretty good reasons for using the HV-70. First, as to the 18 mil, the double thickness makes it more rugged and the health physicists and monitors claim that this is the most important requirement. They actually have tried the 9 mil and it

is not as rugged as the 18 mil. The HV-70 paper we have found is more efficient than the Whatman 41. For routine sampling we have also found that there is an absorption of approximately 30 percent for the alpha material, and 70 percent counting efficiency. This is comparable to the Whatman 41. Another thing, when you have expensive sampling instruments that have been made up for a certain sampling paper it is convenient to continue using them. There are over 300 samples per day taken at Los Alamos with the HV-70 paper 18 mil. This varies up and down for 300 $\pm$ 50. We do use it routinely in Filter Queen units. We use a piece 9 x 4 inches or 36 square inches.

Recently there has been an investigation to get better sampling paper paper for certain types of sampling operations. Since this is an unclassified session we can not disclose the type of alpha material but we have about 5 different types that are sampled. In any case, first I should say the habits of the health physists are to run off samples as long as 7 1/2 to 8 hours per day. In some cases you might have this paper loaded in other places the particle population is so light that at the end of the 8 hours you might have 2 or 3 particles which would be actual tolerance and under a wide variety of conditions. Most of these are done with HV-70 paper. A very important factor is Los Alamos' research and development projects where there are a lot of new materials being used constantly. When you sample for these new materials you like to check yourcounting against chemical analysis. This is the greatest weakness of HV-70. We think ash and insoluble asbestos are troublesome. When you have unusual materials collected on your filter it is literally impossible to dissolve it without getting a great mass of ash. Also, for this reason we are using a lotof Whatman 41. HV-70 is used in Filter Queen units placed in a room and in designated positions. Whatman 41 is often used. We probably never take more than a 30 minute sample with Whatman 41. We use the same

holder and paper as NYOO, the 1 1/8 inch. In fact, I think we got our first stock from Bill Harris.

In addition we do a lot of Cascade Impactor work for routine sampling. We have been finding absorption of 30 percent on the Cascade which is approximately equivalent to HV-70.

There is one question that we would like to raise. We are not completely satisfied with No. 41 on certain types of operations because of its non-uniformity. Harris, I believe, stressed the fact that you had a uniform efficiency. On some of them you can see pinholes and others you cannot. I raise the question that efficiency may not be so uniform as we have been led to believe. Along with the Whatman 41 we have used a lot of molecular filters (MF). We have 8 or 10 Cascade Impactors with molecular filter adapters so it is beginning to be used routinely. At this point I will deviate from the routine operations at Los Alamos to collection of fallout from various Nevada tests. I believe that there is little I can say about the nature of the material from fallouts. You have read about it in the papers and I am sure at least that much is unclassified. Isn't it Les?

Leslie Silverman: (Harvard) Yes, I read about it in the paper. That is the truth. It has been necessary to know they test in the U. S. and collect large numbers of samples.

Mr. E. C. Hyatt: (Los Alamos) They want to know two things, the concentration and the particle size. For the particle size studies we have used about three dozen Cascade Impactors and a lot of molecular or millipore filters. We have obtained some of our most significant results, we think, with the molecular filter as the fifth stage instead of the Whatman 41, for the simple reason that we have obtained material that is not collected with Whatman 41. We have tried both HA and AA, the only difference we can see so far is in pressure drop.

The type S as Silverman has mentioned has been used extensively in the Hi-Vol sampling and also for atmospheric sampling around Los Alamos

up until this year. Again the type S cannot be counted because it is a thick paper. Being about 1 inch thick we cannot count it very decently and you have to ash it.

MSA 2133 which happens to be a flat paper with more efficiency than the type S paper has been substituted and it can be counted readily. This paper can also be ashed. For the work at Los Alamos we are now using thousands of 2133 papers and I think that Harris is also using an equal number all over the United States in their sampling work. We would like to ask this right back at Les. We understood that the efficiency was tested for the 2133 and our tests last spring and our results also indicated that it was very efficient. As a result, there are others now using it on the same type of work and everybody is satisfied with it but we know absolutely nothing about it. The only thing I know is that the BM 2133 is used in respirator pads and carries a Bureau of Mines approval.

Leslie Silverman: (Harvard) I am afraid I cannot answer that because 2133 is a number that does not ring a bell with me. We never tested it. All I remember about respirator pads is that we had used type S in our unit and the next thing I knew was that in our so-called Hi-vol Sampler, the group at M.I.T. has been following NYO in using the flat respirator pads from the Comfo-respirator in place of the pleated paper. We can disclaim honestly responsibility for 2133 except for saying that NYO used it. We never ran any efficiency tests and the only efficiency tests on Hi-vol Samplers have been with regard to the Type S or Whatman papers.

Mr. E. C. Hyatt: (Los Alamos) We ran some interesting tests in various places using two Hi-vols side by side which is always subject to error, of course, out in the open where you do not have comparable conditions with the pleated Type S paper and the Comfo flat paper which is the 2133 approval number. We got approximately 3 times as much on the 2133 paper. We heard that for

certain types of industrial dust, 2 to 3 microns, I believe Type S was 80 percent efficient. We think that we were losing the material in ashing. One of the reasons 2133 is very good is it is rugged and you can not break it. It is literally impossible to break it and it is one of the best papers we have ever run across. It is very nice to count but we do not know the penetration.

Leslie Silverman: (Harvard) How much air can you get through on the Hi-Vol?

Mr. E. C. Hyatt: (Los Alamos) We were getting around 57 cfm at an elevation of around 6,000 feet. Of course, elevation is a volume factor here.

Leslie Silverman: (Harvard) The only thing I know about the efficiency of 2133 is that it passed the Bureau of Mines approval test with Type A dust, which means that it should be between 89 and 97 percent efficient. They use a dust loading of 5 milligrams per cubic meter $\pm$ 1. If you sit down and figure out the efficiencies based on Bureau of Mines requirements, based on the amount passing at the end of the period test, you will find that 0.4 of a milligram after 1 1/2 hours test is permitted with the above loading on a silica dust of 0.6 μ mean size with a given standard deviation. Harvard has never tested No. 2133 filters.

Mr. E. C. Hyatt: (Los Alamos) I would like to point something out about 2133 in some of these investigations. We have found that 2133 increases very little in resistance over quite a long sampling period. In other words, collecting even a fairly heavy mat of particles on the surface makes relatively little change in the resistance across the paper. My explanation for this, it may be wrong, is that the paper tends to stretch with this large volume of air going through it and the pores open up some. It may be that the efficiency is variable and that at the end of the sampling period it tends to go down. That may not be true but I would like to point it out.

Leslie Silverman: (Harvard) Does 2133 have a heavy nap on the surface?

Mr. E. C. Hyatt: (Los Alamos) It has some nap on the surface but you can see a definite low in the paper. It may be stretching and the efficiency may be lower.

Leslie Silverman: (Harvard) We did measure the effect of stretching on sampling papers and Hi-Vol samplers and we checked the area when stretched. We found that there was some stretch but off-hand I would say that the nap was a greater aid to getting a thicker mat on the surface and still keeping resistance down.

Mr. E. C. Hyatt: (Los Alamos) There is one thing we might add, Les, that the Health Physics group and the Industrial Hygiene group at Los Alamos have been meeting in the last month to reconsider and to reevaluate all of the paper and sampling instruments used and we are very interested in this subject because the health physicists frankly admit that they do not think they have the ideal sampling paper or instruments and are ready to listen to anyone who has ideas on anything that is better. The whole field is really open. I understand that there are some projects that have adopted papers and they will not talk about any other. We will. We will talk about other types of papers and if anyone has a better one we are very interested in hearing about it and using it.

Leslie Silverman: (Harvard) We have a representative here from Hanford who has done a considerable amount of work on filter media and also on respirator pads. Maybe he can tell us something about 2133.

Mr. Frank Adley: (Hanford) We use by far CC-6 in greater quantity than we do 41 or any of the other papers due to the fact that it was one of the first high efficiency papers that came out for site use and in addition to being high in efficiency there was more known about it, hence it was adopted for wide use at Hanford. It is used at the present time in large quantities. We use it for off-site monitoring, we have several stations surrounding the plant in the communities. We use CC-6 for that purpose. We use it for in-plant monitoring of buildings and personnel on a fairly routine basis. Over a period of time it was possible

to develop pretty good data on counting efficiency of such paper so we feel that the results are fairly reliable when we count them. On occasions, however, we have come across instances where we wanted a different type of paper, primarily because we wanted to do a chemical analysis on a sample. I think everyone that used CC-6 is aware of the fact that there are constituents such as asbestos which foul up your analysis and for that reason primarily, we went into different papers.

The one we started using was Whatman 41. At the time we adopted that we were involved in studying a uranium contaminated atmosphere contaminated with U_3O_8. Then we sampled with Cascade Impactors, regular special filter heads with just sampling medium and we also used the Hi-Vol samplers. There was a question all the way through as to what we were getting for collection efficiency so when we were well along in the study we thought we had better check back to get performance. We knew the experience with lead fume and dust and other fumes. They had done some work at Harvard a number of years ago. So we were interested in seeing what we were getting for uranium. The atmosphere that we were involved with in the plant was U_3O_8 medium. The particle size was about 0.6 to 0.7 micron and the standard deviation was about 4 to 5. We set up a test procedure in a laboratory and could generate U_3O_8 similar to the conditions in the plant only on a smaller scale. We ran that through the various filter media and from that point into an electric precipitator. Frankly, I have not had much reliance on electric precipitation. When it is working it is a dandy unit, but you can never go away for 5 minutes in the next room and feel that it is doing well. We developed an electric precipitator unit which was made rather precisely as for the circuit and voltage pack, central electrode and the collecting tube. We ran efficiency tests when we got it completed and found out that if we held the central electrode at about 10,000 Kv we could be assured of about 99.7 percent efficiency. We

usually run it up about 14 or 15,000 Kv just to make sure. So we backed the filter media with the precipitator and got a few values. The Whatman 41 filters we set the atmosphere in the laboratory to see just what its characteristics were as to particle size and we ended up with the particle size of 0.5 micron and a standard geometric deviation of 4.9.

In the series of tests which we made on Whatman 41 we found a mean efficiency of 92.2 and 98.8 was the highest value. I think the loading and probably the particle size variation had more to do with the variation in filtration efficiency than anything. It might be that there are pores in the Whatman 41 which pass the fume.

We also checked the MSA pleated filter, that is, the Type S that we get from MSA, and it was found that they were fairly high in efficiency but not dependable by any means. Not as dependable as Whatman 41 which in itself was not too good. The pleated filter tests varied from 97.3 to 99.4 which was the highest value for unimpregnated pleated units.

Leslie Silverman: (Harvard) Did you count these?

Frank Adley: (Hanford) No. They are chemical analyses. Radiochemical analysis all the way through. We are not through with this study yet by any means although I do not mean it is going to be an extensive study. We still have a few more things to investigate. Just before I came away we had some AAA Hurlbut's glass-fiber medium around, X935, and we got that from Al Blasewitz. I do not know whether Al is here this morning or if he has gone home, but I am not sure just where he got it. It is identified as Hurlbut's No. X935. The tests that we have run on that, so far, are well over 99 percent in efficiency with the exception of just two samples which for some reason were low (I call low 98.7 and 96 percent). The others were well over 99 percent.

Anonymous: May I ask at what rate you ran the Type S?

Frank Adley: (Hanford) We varied from 12 to 180 cfm.

One interesting feature about the AAA medium that we found in the test arrangement I told you for testing with U_3O_8, was that when we placed the AAA fiber medium in the holder and started using it as we had with the Whatman and the pleated filter medias, we found that a disc ruptured. This got us interested in whether filters had any decrease in strength under various loadings. With clean media we ran a series of tests for various pressures and found the following results. We had a 2 inch opening and placed the filter between 2 plates. We increased the flow of air through the test media until the pressure drop read up to 0.75 inches of mercury at which point it burst. We decreased the size from 2 inches to 1 1/8 inches and the inches of mercury bursting pressure on 2 tests was 1.9 and 2.4. Getting still smaller openings down to 1/2 inch resulted in values of 4.5, 4.5, and 7.5. It turned out that the pressure to burst through a 1/4 inch open suspension was 16.6 inches of mercury.

In another series of runs we made we placed the filter in between the plates and introduced uranium fumes from the chamber through 1/2 inch openings. We found that when the load was 0.2 milligrams per square inch, bursting occurred and that pressure was 2.3 inches of mercury. Correspondingly, through the same 1/2 inch openings with a 1.34 milligram per square inch the bursting pressure was 5, with a load of 2.5 the bursting pressure was 6, with a load of 3.2 the bursting pressure was 7.5, etc. That just about covers the tests we have run up to date.

There is one thing I thought of this morning which I want to mention here in connection with filter tests and the efficiency of collection of various sampling devices. It goes back to Dr. Lapple's statement yesterday that we have an air cleaning device which was supposed to be 99.999 but how many 9's do we finally add on to 99 when we get through? Assuming we have

an serosol of say 100 units entering a filter medium and that filter is 98 percent efficient, you will have two units going through. Although your device is actually 98 percent efficient you might be sampling the upstream influent with a sampling entering device which is 99 percent efficient. Downstream where the material is usually either a lower particle size you probably get a lower efficiency, say 85 percent, or you end up with an assumed efficiency of the air cleaning device if you want to carry it out far enough. If you are concerned with stating efficiencies of air cleaning devices you should not lose sight of the efficiency of your appraising device. Sometimes it makes an appreciable difference, especially when you are up around 99 percent efficiency. When you are down around the lower efficiencies (60, 70 and 80 percent) it does not make a great deal of difference but you might be interested in more accurate results in high efficiencies.

Leslie Silverman: (Harvard) Frank brought a good point up with regard to the testing of air cleaning devices. We have run into the same problem and for that reason tried to get as efficient a sample for that purpose as possible.

George Payne: (Argonne) Argonne's problems may provide some answer to 9 mil versus 18 mil HV paper. I recall some of the things that were studied in the early days, and one of the papers tested is one, I think, that you probably made Dr. Stafford. This was an asbestos suspension on a very fine tissue. At that time we were using one of the NDRC papers and I remember that the harder paper would result in less absorption.

I think that one other point I should make clear at this time is the fact that our laboratory has not had an industrial hygiene section for a very long period of time. If enough people can be trained by Silverman, we can hire them. Meanwhile we hope to build up an organization to do some particle size work. At this time we have done practically nothing

in this field.

I think that many of you people here realize that much of this work was done during Metallurgical Laboratory days and the HV-70 paper was essentially the NDRC paper made at the requests of them to Dr. Stafford. We are continuing now and had used these papers during this whole period of time. We have done beryllium sampling and have used Whatman 50 for this purpose. I cannot give you the reasoning behind the choice of that particular paper. I do know that it satisfies the chemists who do this analysis and we are able to collect sufficient quantities of sample in the standard filter holder in order to get reliable data.

Within the last two or three years we have added a background analytical group to the Radiological Physics Division and Andrew Staney is the chemist in charge of this particular group. He is now making studies of outside air and he has been using the HV-70, 9 mil paper. As mentioned here the chemical handling is a very major problem and we propose to use millipore filters after we have done some work with them and feel that they satisfy the chemical handling aspects.

One of the problems, I think that I do not feel particularly clear on, is the fact that with the proposed reduction in permissible levels for the alpha emitting materials which we are primarily interested in, I should say, for good statistical reliability the volumes of air that can be handled and collected in a short period of time are going to play an important role. The resistance or pressure drop and the paper filtering velocity I think are going to play a role in the absorption efficiency. I think that if going to higher increased velocities in order to collect reasonable quantities of air in a reasonably short space of time is going to play a role in the absorption phenomena in the paper. This is something that ought to be investigated thoroughly. With the proposed reduction it is going to make the air problem much more difficult to evaluate. As I said, our investigations

have been practically nil and I do not believe I can add anything more to the description.

Leslie Silverman: (Harvard) One thing that comes to mind after this discussion today is do we need standard methods of air sampling and, if so, what are we going to standardize on? If we are not in that position what areas or investigations are needed to solve some of these problems that have been brought up in the discussion this morning? I would appreciate some comment from the group as to whether or not we are in a position to standardize on 18 mil or 9 mil HV-70 or standardize on Whatman 41 until Harris' supply is gone, or if we should standardize at all. The floor is open to discussion on the point. Is there any discussion from the floor on the question of whether we should standardize or try to get one thickness of HV-70 adopted. Aside from the handling or strength standpoint I have not heard a great deal of reasoning behind 18 versus 9 mil paper. I suppose it will be troublesome to close the Filter Queen that has a double thickness of paper in it, but I believe any of the sampling heads for this instrument will take 9 or 18 mil paper.

Mr. Stafford: (A. D. Little) I have a few comments on these papers. As long as you are buying a known filter which is of good quality you will get good results but if the company or source should change they do not know what they are getting. AEC people are buying these papers just by name but they do not know what they are getting and there is nobody in the Commission whose duty it is to test these papers and find out if they are constant in quality. Now you talk about tests made on Whatman 41 a few years ago. Well, Whatman 41 today or next month may be quite different and nobody knows it and you use the data that we made for the paper that Whatman was making at that time. The Whatman's papers are made, of course, for chemical filtration and they are tested primarily for that. There could be considerable change from one

year to another. If they can get the proper kind of rag their paper has certain characteristics of interest to AEC but perhaps a year from now they may be using a different material and their paper is different and except for the filter paper for the space filter there are no specifications or no definitions of these things except by number and they come from certain manufacturers. I have been interested in the S+S paper and that is made in this country. Somebody concerned can go to the mill and have them understand what the requirements are and make sure that they are fairly uniform from year to year. Whatman is made in England and they make a great many grades. While they are wonderful paper makers, they make primarily for the chemical laboratory which is wet filtering and I do know there is a big variation in certain sheets of Whatman 41.

Leslie Silverman: (Harvard) I would like to suggest that in order to make sure we get consistency in HV-70 or its equivalent, that some specifications be made up that can be duplicated by paper manufacturers and that we come to some agreement about an all-cellulose paper which is comparable in resistance and filtering characteristics to anyone of the Whatman or other series. The group should accept this media for their purpose to avoid the problem of item No. 3, (Table 1) uniformity, because as Mr. Stafford indicates, you may have Whatman 41 of one type today and something completely different tomorrow. Most of us cannot buy a 10 year supply such as Harris has and even in that supply there may be a good deal of variability.

Mr. J. A. Lieberman: (AEC) Is there any information available on the roughly comparable efficiencies, for a given aerosol, between the AEC paper or the CC-6 paper and HV-70?

Mr. Stafford: (A. D. Little) Well, HV-70 is practically the same formula as CWS-6 except that it is beaten a little more and made a little stronger. It has about the same efficiency for DOP but its resistance is 50 percent or

maybe double what the other is. Its surface is harder and that is why you like it and can handle it. I do not know how Hollingsworth and Vose makes it but they probably have not made more than three or four runs because they make the paper by tons and you use it by little discs. This is one trouble in any new paper such as the one Les mentioned, that is paper of Dynel fiber. They can make up some hand sheets but it is a tremendous step to get that in production. No paper mill is interested in doing it unless they are sure of carload lots and it costs a lot of money to do it.

As for this glass paper I think that you may be able to use this Hurlbut paper. They are excellent paper makers and they are using a very uniform finish.

About the asbestos sheet that has been mentioned here, if sheets of plain asbestos such as we have made by hand prove to be valuable, I am quite sure you could never get it made in a paper mill. It would always have to be a laboratory operation. There is one exception to that and in the contacts I have had just recently that there might be some hope. Johns-Manville is now making, in a small mill in New Hampshire, all asbestos sheet made of Canadian asbestos which is purified and is used for bable wire. If asbestos sheets could be used, there is a commercial source. It is not very strong, I would say it is only about 5 mils thick, but Canadian asbestos makes a stronger sheet than any other kind and that could be used for sampling. Has anyone ever heard of it and tried it? If not, I would be glad to get a sample and send it to anyone who is working with asbestos.

Mr. J. A. Lieberman: (AEC) What I was leading to was this. Since the AEC has a specification for the production of space filters we have, almost ipso facto the specifications the mill must meet to make the media that go into these filters. If the paper itself is suitable why can we not kill two birds with one stone, i.e. use it for a sampling paper?

Mr. E. Stafford: (A. D. Little) Well, I wondered why you did not use the space filter paper.

Leslie Silverman: (Harvard) Penetration is the most important problem. If you use the same composition but calender it thinner then it might be suitable. In other words, I gathered from what Mr. Stafford said that the composition of HV-70 may be variable.

Mr. E. Stafford: (A.D. Little) Yes, on Whatman but not on HV-70. I am quite certain that they use the same composition as they use on AEC but they treat it different to give it more strength and therefore its resistance is high but they make it so that the penetration is about the same or maybe a little better.

Leslie Silverman: (Harvard) I do not think the supply problem should be too bad. I do not know whether I am saying things out of turn but I think if everyone got together a large enough supply could be purchased to take care of the sampling needs for a long time.

Mr. E. Stafford: (A. D. Little) I think that would be an ideal way to do it then all samples would be alike.

Leslie Silverman: (Harvard) Well, maybe Joe (Mr. J. A. Lieberman) and Art (Arthur Gorman) would look into that phase.

Mr. Arthur Gorman: (AEC) This is the second year now in which this thing has been discussed. I think if the group here who use these papers would indicate what they want and we could get a good consensus on the criteria they want these papers to measure up to, we can get AEC to follow through and get the papers you want and identify it with an AEC number for AEC work that everybody understands. We do need your judgement as to what you need and if you are going to have one, two or three types of paper. I am hoping that out of this discussion we can get something that will give us some facts to use.

Leslie Silverman: (Harvard) I gather that from our discussion this morning and our discussion last year that there are about three kinds of paper that would satisfy all of the

needs. One which is the HV-7C or its equivalent, the other which is Whatman 41, 44 or its equivalent and the last one some high volume media such as used in the 2213 or the Type S filter. I do not presume to say that we ought to boil it all down to one and get rid of the three. Mr. Harris indicates he thinks it can be reduced as two types.

Mr. William Harris: (NYOO) I do not see why the characteristics of the HV-70 and the Whatman paper cannot be combined into a single sheet.

Leslie Silverman: (Harvard) That obviously means eliminating asbestos if that is correct. In other words, would everybody here be happy if we had an asbestos free paper? I do not think everyone agreed but that is exactly what I believe Mr. Harris is proposing, that we get an all-cellulose paper or low ash paper with efficiencies that are high and consistent.

Mr. E. Stafford: (A. D. Little) The trouble with most organic fibers is that they are hard to produce uniformly.

Leslie Silverman: (Harvard) Let me ask this question, Walter and Earl. What can we expect in an all-cellulose paper?

Mr. Walter J. Smith: (A. D. Little) There is one possibility there to give some consideration to but we have not had the fiber to try as yet. As you know, when you beat a cellulose fiber, just let me point out one thing further. Some people think that a paper filter has a binder to hold it together. That is not so and if you watch these fibers as they are worked in water they begin to soften and fragment. Under some circumstances you can keep their shape and press them into a sheet.

Leslie Silverman: (Harvard) Well, it would appear if we do any standardization that it should be on a low ash paper. Now, obviously, in making low ash paper they treat the pulp by acid extraction. That will be one of the requirements because the Whatman 40 series are relatively ash free. If we are going to standardize or get a uniform paper used it must be ash free. I think we can agree to that.

Mr. William Harris: (NYOO) The second filter type is the high volume filter.

Leslie Silverman: (Harvard) Now that one is an ash problem too, isn't it?

Mr. William Harris: (NYOO) No, that is not much of an ash problem because when a sample is taken 24 to 48 or even 72 hours, you get so much material on the filter that the ash content of the sample itself is not significant.

Leslie Silverman: (Harvard) How about yours, Ed. Is ash a problem there?

Mr. E. C. Hyatt: (Los Alamos) I think it is.

Leslie Silverman: (Harvard) We have a difference of opinion, Frank?

Mr. Frank Adley: (Hanford) I do not want to argue but there are many cases where you run a high volume sampler because the concentration is very low.

Leslie Silverman: (Harvard) Well, I do not want to get involved in a long discussion on this. Apparently Art, there is some need of an ash-free all-cellulose filter which I think our friends at A. D. Little are in the best position to make. The question of specifications for an asbestos paper media apparently exists in AEC No. 1 or CC-6 paper. It is a question of that paper being too difficult to handle, although Hanford uses it in their sampling program. I think what we should do is have a conference of those people that are directly interested as we had proposed last year as to what exact specifications must be drawn up and I would like to leave it that way if it is agreeable to the group.

Walter J. Smith: (A. D. Little) I believe a questionnaire would be desirable to circulate to get response of interested people.

Leslie Silverman: (Harvard) Well, I think that would be a good idea if you would assume the burden of making up a questionnaire for the poll and see what sort of response you get. I think all of those here would fall in line with that. You might get such a variety of answers that you would be right back where we started this morning but I think we now have a pretty good idea as to what we need. We could boil down at least seven different sampling media into possibly two.

Mr. George Payne: (Argonne) In discussion this morning several of the installations are rather large and apparently are limited to various test facilities but there are a number of installations which have essentially no testing facilities for efficiencies of various other items like this. It would be very nice to have available some booklet which might describe quite adequately some of these papers for outside uses.

Leslie Silverman: (Harvard) I think that can be done after we agree on what can be expected of these papers. I think that would be part of the program.

Arthur Gorman: (AEC) We will initiate an action towards getting some results if everybody here would talk with the people back home as to what they want and when we write out to you for the information give all the data you have. I think a year from now we will be pretty well along.

Dr. Melvin First: (Harvard) I think Les, there are two problems involved here. One is to decide which papers are now available that you want to use and secondly, the development of a new paper if it is desirable, if the ones that are now available do not meet the requirements. In any standardization, I think we should start with what is now available.

Leslie Silverman: (Harvard) What is available now is not very standardized as I gathered.

Dr. Melvin First: (Harvard) No, that is exactly it. If a step was to be made in standardization, one problem would be to consider what is now available and standardize on a few types temporarily and simultaneously do a development program for developing new types which would be more satisfactory than what is now available.

Leslie Silverman: (Harvard) I gather that the questionnaire should accomplish the first part of that program and the second part should result from what sort of dispersion we get in answers in the questionnaires.

Dr. Melvin First: (Harvard) That possibility might also be raised in the questionnaire as a special item.

Dr. Leslie Silverman: (Harvard) I think that is part of Walter's job and we can give him some help on that. One thing I would like to know is whether or not this type of meeting is worth repeating again within a year or two. As you know from our discussion, a good portion of it is for training of people unfamiliar with air and gas cleaning problems. We have had a representation here of about 60 percent with regard to previous attendance and contributions and we still want to keep on training if there is any real need for it. It is quite evident, at least from my standpoint, that it is worthwhile to get together at yearly or intervals close to that range and discuss progress on these problems. I would like to get some ideas as to the sentiments of the group in that regard. Is this worth repeating in a year or two? Do you have people at your site or location that would be interested in the review part of the work and do you have people who would like to contribute to the air cleaning aspects or gas cleaning aspects of their program? Any discussion on that?

General discussion resulted in a unanimous opinion in favor of repeating the seminar within a year at a different site with emphasis on new developments.